

**Convective-scale Warn-on-Forecast:  
The Severe Weather Forecast Improvements Project**



**Summary of Year Three Research Activities  
March 2012 through February 2013**

## Executive Summary

Increasing lead time and accuracy for hazardous weather and water warnings and forecasts in order to reduce loss of life, injury, and damage to the economy, is one of the main objectives of the weather and water strategic mission goal for the National Oceanic and Atmospheric Administration (NOAA). Trends in yearly-averaged tornado warning lead time suggest that the present weather warning process, largely based upon a *warn-on-detection* approach using National Weather Service (NWS) Doppler radars, is reaching a plateau and further increases in lead time will be difficult to obtain. A new approach is needed to extend warning lead time in which probabilistic hazard guidance is provided by an ensemble of forecasts from convection-resolving numerical weather prediction models. This convective-scale probabilistic hazardous weather forecast system is called *warn-on-forecast*.

This document summarizes the research efforts that will be conducted during the third year of the warn-on-forecast project from March 2012 through February 2013. Efforts during the first two years were largely pointed towards laying the foundation for the program's success, such as hiring needed staff and strengthening our collaborative research activities. The research efforts during this third year show more clearly the directions the project is taking and how the different groups are working together. The activities of each organization that receives funding from the warn-on-forecast project are summarized in the following sections, along with any deliverables. This document is required as part of the annual planning process for the project and is an important component of the project management structure.

The warn-on-forecast project represents a collaborative effort across several NOAA units and academia. The project is led by the National Severe Storms Laboratory, with substantial NOAA contributions from the Earth System Research Laboratory, the Storm Prediction Center, and the Norman NWS Forecast Office. Academic collaborators are the Center for Analysis and Storms and the Social Sciences Woven into Meteorology Program within the Cooperative Institute for Mesoscale Meteorological Studies at the University of Oklahoma.

## **2012-2013 Research Activities**

### **NOAA/OAR/National Severe Storms Laboratory**

During the third year of the warn-on-forecast project, the National Severe Storms Laboratory proposes to accomplish the following tasks:

- Continue to develop quality-controlled data sets for use in assimilation and quality control (QC) algorithm testing. This work involves the manual editing of radar data to fix velocity de-aliasing errors and the removal of reflectivity artifacts. Each case may have data from multiple WSR-88D radars. We will also gather supplemental data sets for each case, such as model analyses and forecasts, surface and upper-air observations, and satellite data. All the data will be made available to project participants over the Internet.
- Document the performance of the automated radar QC methods implemented during the second year. Evaluate and implement new techniques as needed. Apply these automated techniques to radar observations in a sequential approach to reduce the amount of manual editing required for creating quality-controlled data sets. The intent is to be able to pass the radar observations through a clutter filter followed by a filter to remove non-precipitating echoes followed by one or two de-aliasing algorithms in order to remove a large fraction of the questionable observations prior to either manual editing or assimilation in numerical models.
- Starting with the radar data converters developed in year two, implement a web-based interface to allow participants to convert between the most common radar data formats and perform automated radar quality control on datasets without the need to download and compile software.
- Create analyses using a three-dimensional variational (3DVAR) system to assimilate radar observations in real time over several 200 x 200 km domains in support of the Hazardous Weather Testbed (HWT) Experimental Warning Program. Examine the 3DVAR analyses during the HWT to assess the value of these analyses in comparison to other radar products available.
- Continue real-data case studies using an ensemble Kalman filter to assimilate WSR-88D and other routine observations into a ~2 km grid spacing configuration of the Weather Research and Forecasting (WRF) model using the Data Assimilation Research Testbed (DART) square root filter software developed at the National Center for Atmospheric Research. Explore ability to provide these data for displaced-realtime experiments in HWT.

- Explore the potential for using a 3DVAR approach to start an ensemble Kalman filter data assimilation system.
- Continue development of a hybrid 3DVAR approach for radar data assimilation.
- Evaluate impacts of microphysics parameterization on radar data assimilation analyses and forecasts.
- Begin developing a framework for the inter-comparison of different radar data assimilation schemes in collaboration with ESRL/GSD.
- Collaborate with the other project partners in exploring complex issues related to the frequent updating of convective-scale models, both deterministic and ensemble systems. Begin to look at ways to include satellite observations in the assimilation process.
- Continue to lead effort with other warn-on-forecast partners to develop a unified plan for social science research activities.

#### Deliverables:

- Continue to develop new quality controlled and supplemental data sets for several cases and make them available to project partners.
- Successful completion of the HWT Experimental Warning Program with assessment of the performance of the 3DVAR analyses for assisting warning operations.
- Continue to assist Norman NWS FO as needed in using 3DVAR in their hourly WRF model forecasts.
- Archival of the 3DVAR assimilated fields and corresponding data sets (radars, etc.) from real-time operations.
- Development of web-based interface for radar data converters and radar QC.
- Evaluation of automated radar QC methods in sequential form and testing on available manual QC data sets.
- Initial results from real data applications of ensemble Kalman filter to the assimilation of radar observations from a supercell thunderstorm case and a mesoscale convective system case.
- Develop a website for sharing data for selected cases of interest.

## **NOAA/OAR/ESRL/Global Systems Division**

During the third year of the warn-on-forecast project, the Global Systems Division proposes to accomplish the following tasks:

- Demonstrate cycled regional storm-scale radar-data assimilation and forecasting for a retrospective (e.g., 27 April 2011 tornado outbreak) and/or near-real-time period. Radar and other observations will be assimilated every ~10 min for ~1 day, and forecasts will be produced at regular sub-hourly intervals. Multiple radar-data assimilation methods will be tested, including EnKF, 3DVar, and reflectivity-based diabatic forcing. GSD and NSSL will work together on this project.
- Collaborate with NCAR, TTU, and NSSL on VORTEX2 retrospective modeling and numerical weather prediction, particularly for the 18 May 2010 Dumas, TX and 13 June 2010 Booker, TX supercell cases. Multi-scale analyses will be produced through EnKF assimilation of standard and VORTEX2 (mobile radar) observations.
- Apply storm-scale ensemble sensitivity analysis to a severe weather event.
- Collaborate with NCAR on identifying WRF model biases.

Deliverables:

- Web graphical output for the cycled radar-data assimilation and forecasting system, discussed with project partners and presented at the Warn-on-Forecast workshop.
- Results of VORTEX2 case studies presented at AMS conferences and Warn-on-Forecast teleconferences.
- Initial results from a storm-scale ensemble sensitivity analysis presented at Warn-on-Forecast teleconferences and Warn-on-Forecast workshop.

## **NOAA/NWS/NCEP/Storm Prediction Center**

During the third year of the warn-on-forecast project, the Storm Prediction Center proposes to accomplish the following tasks:

- Begin to establish a forecasting framework for the watch time scale (1-6 hours) including the development of a short-term outlook or mesoscale discussion product, which can be evaluated and used as a performance tool for different data assimilation and analysis systems on the mesoscale.
- Leverage the 2012 CI object detection framework for use in severe weather forecasting.

- Continue developing visualization techniques and information extraction approaches applicable to real-time and research analysis and data assimilation systems. This includes statistical approaches for gridded data and the generation of databases on individual storm objects. The linkage of these data sets with soundings will be a high priority.
- The development of a model evaluation framework for both objective and subjective purposes will be tested. Emphasis will be placed on deriving the strengths and weaknesses of data assimilation data sets.
- Continue working closely with local partners (OCS and OU) to integrate social science methods for model evaluation, uncertainty communication, and novel ways to communicate sophisticated forecast information.

#### Deliverables:

- Successful completion of the 2012 Hazardous Weather Testbed Experimental Forecast Program with a convection initiation desk.
- The integration of the storm object database and a modeled sounding viewer will be implemented.
- Continuation and expansion of visualization capabilities with CAPS and NSSL.
- Creating greater opportunity for relevant social science to be conducted as part of the HWT. At least 1 student project will be performed.

### **NOAA/NWS Norman Forecast Office**

During the third year of the warn-on-forecast project, the NWS Norman Forecast Office proposes to accomplish the following tasks:

- Study how forecasters use convection-allowing models in operational forecasts.
- Ascertain how high-frequency updates impact forecaster thinking by comparing forecast updates with verification.
- Utilize data collected during the 2012 Experimental Warning Program to develop guidance for using high-resolution modeling in an operational framework. .
- Compare forecasts starting from a LAPS analysis with those starting from a 3DVAR analysis.

- Work with other warn-on-forecast partners to develop a unified plan for social science research.

Deliverables:

- Report describing the use and impact of convection-allowing models in operational forecasting.
- Summary of best practices concerning the use of convection-allowing models in operational forecasting.
- Initial comparison of forecasts started using LAPS versus those started using 3DVAR.

## **University of Oklahoma/Center for Analysis and Prediction of Storms**

During the third year of the warn-on-forecast project, the Center for the Analysis and Prediction of Storms proposes to accomplish the following tasks:

- Generalization and testing the ARPS EnKF system (based on the EnSRF algorithm) for multi-scale observations (radar, surface and upper-air obs), and improving its capability and parallelization efficiency for simultaneous assimilation of data from a large number of radars, and radars of different scanning characteristics and wavelengths.
- Complete the implementation and testing of the ability for the parallel ARPS EnKF DA system to work directly with WRF ARW model, including the four-dimensional asynchronous EnSRF (4DEnSRF) DA capabilities.
- The EnKF algorithms (EnSRF, 4DEnSRF and optionally LETKF) will be tested initially with OSSEs, then applied to common cases and data sets chosen for DA inter-comparisons within the WoF project.
- Work to establish an ensemble-based data assimilation system that can be run in realtime in cycled mode, assimilating data from multiple radars as well as other conventional platforms, and test such an system during the HWT spring programs. We may need to interface the chosen DA system with the operational data stream used by Rapid Refresh/High-Resolution Rapid Refresh and use GSI as the data processor if we want to carry out independent continuous cycling. Or perform partial cycling initially, by restarting periodically from the operational analyses. We hope to achieve this goal in spring of 2014.

Deliverables:

- Complete source code for the parallel EnSRF that couples to the WRF model.

- A working example (run scripts, IC's, observational data sets, verification data) for two convective cases.
- Basic set of documentation to run the examples.